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Future Command and Control on the Move for the Objective Force

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ABSTRACT

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Currently, there is an information void for commanders, their staffs and soldiers while on the move. One of the Army Transformation goals is to deploy a brigade size combat force to anywhere in the world within 96 hours and have that force fully capable of warfighting, which means maintaining updated situation awareness while enroute to the objective. This is not the case for Enroute and Early / Forced Entry forces today. Initial work is underway to address the shortfall, but this beginning is fraught with concept of operations and technical challenges. My research will look beyond the current static, Battle Command concepts and technology towards the future as it relates to the Objective Force. I will focus on Army requirements for airborne, seaborne, and groundbased “on the move” operations with emphasis on Enroute Mission Planning and Rehearsal. I will address the concept of operations for Command and Control on the Move (C2OTM) and highlight some of the technological capabilities that will help establish the Objective Force Initial Operational Capability in the 2008 timeframe.

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INTRODUCTION

> "This window of historic opportunity will grow narrower with each passing day. We can transform today in a time of peace and prosperity. Or we can try to change tomorrow on the eve of the next war, when the window has closed, our perspective has narrowed and our potential limited by the prowess of time and the constraints of resources."[1]
>
> —General Eric K. Shinseki

In October of 2000, at the annual Association of the United States Army convention, the new Chief of Staff of the Army unveiled his vision for the Army of the new millennium. General Shinseki introduced the effort to transform the Army from a heavy armor oriented force into an agile, lethal and rapidly deployable force capable of responding to a broad spectrum of challenges. These challenges range from peace keeping to limited regional conflict with terrorists and non-state actors to full-scale theater level war.

A major aspect of transforming the force is establishing effective command and control of the power projection Army in various modes of operation. The purpose of this paper is to explore future airborne, sea-borne, and ground-based Command and Control on the Move (C2OTM) concepts and technologies as they relate to Army Transformation and the Objective Force. "In viewing the modernization of legacy forces and the requirement for the commander to execute offensive-oriented and distributed operations throughout the assigned battlespace, C2OTM becomes the maneuver commander's essential capability to fight decisively forward and create a commander-centric, mission-focused organization instead of a Tactical Operations Center (TOC) - centric organization. In the expanded battlespace of digitized division operations, placement of key people and facilities is important. The maneuver commander may opt to position the command vehicle in a location that distributes senior leadership in depth throughout the area of operations, allowing observation and command presence at a decisive point."[2]

Command applies to the leadership element of combat power. It is an art that employs skills developed by professional study, constant practice and considerable judgment. Battle command provides the necessary leadership, direction and motivation to achieve decisive action responsive to the situation to include strategic and tactical implications. Battle command

is essentially how leaders think - leveraging dominant knowledge to achieve decision superiority, thereby giving warfighters an actionable understanding of the battlespace. Battle command synchronizes and integrates operations of Army forces with other Joint elements to conduct dominant maneuver, focus logistics, execute precision fires and provide full dimensional protection. Battle command focuses on the ultimate executor of military power - the individual Soldier.

Army operations in 2008 will continue to center on the soldier who will have superior warfighting capabilities through unprecedented advances in technology. The Army views the science of battle command as the essential bridge between advanced technology and enabling soldier operations. Technology is merely a catalyst for execution of battle command and enhanced mission success. Critical to exercising battle command is to understand the distinction between the art and science and to integrate people and technology in a synergistic fashion.

Battle Command On The Move (BCOTM) is the Army's initiative to identify and refine the requirements that provide the maneuver commander the wherewithal to effectively execute his battle command responsibilities while detached from his command posts. The concept of operations is that a commander, when provided with a communications suite exploiting horizontal technology in a light armored, mobile surrogate platform will enable near real-time Situational Awareness. The command and control capability can effectively enable the commander to see, decide and act while traversing the modern battlefield. This goal has application to the legacy force division, brigade or battalion commanders and interim brigade and division commanders. It may also provide an early entry command and control capability, define emerging requirements for the Objective Force and provide insights on lightweight, multi-functional alternatives to tactical command post configurations.[3]

COMMAND AND CONTROL INFRASTRUCTURE

The Warfighter Information Network -Tactical (WIN-T) is Army’s Objective Force tactical telecommunications system consisting of infrastructure and network components from the maneuver battalion to the theater rear boundary. The WIN-T network provides Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) capabilities that are mobile, secure, survivable, seamless and capable of supporting multimedia tactical information systems. The network’s capability to support unit task reorganization and real-time retasking of battlefield support elements is a vital enabler for Army 2010 and beyond operational concepts. The WIN-T network will allow all Army commanders and other

communications network users at all echelons to exchange information internal and external to the theater. They will be able to communicate via wired or wireless telephones, computers (Internet like capability) or from video terminals. Warfighter and signal units employ their organic WIN-T systems to integrate wide and local area battlefield networks into a commercial information technologies-based tactical network. WIN-T, in turn, connects all users to each other from theater down to the maneuver battalion, to Joint and multinational elements, and the Defense Information System Network (DISN). WIN-T employs a combination of terrestrial, airborne, and satellite-based transport options, to provide robust, redundant connectivity. WIN-T supports the warfighter's requirement for C2OTM by integrating the major WIN-T elements into warfighter mobile TOC platforms and leveraging the Joint Tactical Radio System (JTRS), legacy wide-band digital radios, and wireless local area network (LAN) technologies.[4]

The heart of the Army's command and control system is the Army Battle Command System (ABCS), which includes command and control systems to support decision-makers from platform level to theater level. The ABCS has several components:[5]

- The Global Command and Control System - Army (GCCS-A) supports warfighter information and understanding at the theater level, including the Joint environment.
- The Army Tactical Command and Control System (ATCCS) is the integration of five primary functional area control systems providing situational information and decision support to the Battlefield Operating Systems from corps to battalion echelons.
- Force XXI Battle Command Brigade and Below (FBCB2) provides access from brigade to the individual platform.
- Other support systems closely tied to the ATCCS are the Digital Topographic Support System providing geospatial data and the Integrated Meteorological System providing weather data to the ATCCS. ABCS is supported by a robust communications architecture backbone.

A primary source of communications for the Objective Force at the tactical user level will be the JTRS family of radios. JTRS satisfies a core set of requirements common to the three domains that coincide with operational missions and environments: airborne, sea-borne and ground-based forces. The family of radios under development will provide simultaneous multi-band, multi-mode communications that use existing and advanced data waveform capabilities to ensure the timely C2OTM and global navigation information. The JTRS will operate with legacy

equipment and waveforms currently used by military and civilian land, air, surface ship, subsurface, man-mobile and vehicular platforms incorporating new waveforms as they are developed. The radios will be scaleable by virtue of form, fit and cost to meet specific user operational needs. JTRS will also provide growth capability through an open system architecture that enables technology insertion through evolutionary acquisition or preplanned product improvement. The JTRS will be capable of higher channel data throughput rates, incremental channel expansion, high levels of reliability, maintainability, and availability, enhancement, and commercial support service compatibility. The family of radios will enhance warfighter interoperability by conforming to appropriate standards and specifications of the Joint Technical Architecture.

The JTRS operational concept is to provide warfighters with a C2OTM capability via digital radio communications throughout the battlespace. In order to achieve this operational concept, JTRS will provide task-organized warfighting elements that require communications across both vertical and horizontal hierarchies with seamless, high speed, and digital information exchange within the battlespace. The JTRS will allow operators in the field to expand and modify the capacity and capability of individual radios, links and networks to accommodate user demand as it becomes known. The JTRS will be employed worldwide in both hostile and non-hostile environments, and in a variety of terrain and climatic conditions. The JTRS will support Joint and Combined/Coalition operations by providing the capability to transmit, receive and bridge between similar and diverse waveforms over multiple communications media and networks. The JTRS will operate in existing TOC shelters and vehicles like the Stryker and ships such as the Army's Theater Support Vessel (TSV). It will operate from Air Force aircraft including C-130s and C-17s, buildings, on the ground with the Objective Force Warrior, and in planned future systems in conformance with applicable service or agency requirements. Finally, the JTRS will be capable of being operated and monitored while unattended and remotely controlled.[6]

ENROUTE PHASE

The purpose of all of the aforementioned communications devices is to enable the Objective Force to maintain situation awareness from the pre-deployment phase through sustained operations on the ground. Paul Chernek, Deputy Training and Doctrine Command Systems Manager for Satellite Communications shares in the notion of "on the move" communications supporting phased operations. He is considered the preeminent expert in Army satellite communications and has written and briefed extensively on the subject. In

Chernek's Army War College strategic research project, he addressed the Enroute and Early / Forced Entry phases of deployment in the context of satellite communications. However, the same phases apply to the broader C2OTM environment.

> "For a forced entry scenario, the vast majority of the task force and command group will deploy by Air Force aircraft. The key to command and control for the Corps/Division commander while enroute to the objective area is the ability to communicate with various command elements for current situation and intelligence reports as well as mission changes/updates. These elements would include the Joint Task Force (JTF) Commander, AWACS/Reconnaissance aircraft, National Continental United States based intelligence systems, the Division Ready Force commanders, Air, Marine, and Naval force commanders, coalition commanders, and Special Operations "eyes on target" Forces. In a highly volatile scenario, coordinated preemptive strikes against enemy targets, led by the Air Force or Navy may be necessary. Real-time battle damage assessment (BDA) of the initial strikes will provide critical information to the enroute forces prior to their execution of the forced entry phase. Today, due to the mature technology and low cost of implementation, single channel Ultra High Frequency (UHF) Satellite Communications (SATCOM) provides the primary links between the enroute platforms and the various elements. This in many scenarios involves linkage between multiple satellite coverage areas simultaneously. The Secure Enroute Communications Package - Improved (SECOMP-I) is a JTF/Corps, Division, Brigade asset used today to support the corps commander, his subordinate commander and principle staff during airborne deployment and during air assault operations. The system is comprised of an Army single channel UHF SATCOM radio connected to a hatch mount antenna, an Army line-of-sight Frequency Modulated radio, an Air Force aircraft High Frequency radio, communications security and radio control equipment, and computer equipment hosting a variety of command, control and intelligence applications."[7]

> "The ability to receive large data files/imagery/video products in a more timely fashion while enroute is driving an emerging requirement for high data rate transfer to commanders in enroute aircraft and vessels. BDA from national intelligence sources is one example of this type of data transfer. For example, secondary still image products from a national source are 2048 x 2048 pixels or 33.5 megabits in size. With today's technology, these images can be compressed to 8.4 megabits for transmission. At a 16 Kbps transmission rate, it would take approximately 525 minutes to transmit this image. Therefore, the Army is pursuing wideband solutions that will enable higher speeds. Transmission speeds of T1 (1.544 megabits per second) directly to small user receive terminals, would enable transmission of today's compressed image in 5 to 6 minutes."[8]

Future improvements in compression technology, or increases in data rate transmission speed will improve upon this performance. Again, due to limited space available on transport aircraft and vessels, the receive terminals must be made as small as possible. Figure 1. illustrates the C2OTM concept. Forces maintain continual situation awareness through inter-

connectivity and intra-connectivity with higher, lower, lateral and subordinate forces. Multiple communication paths support operator transfer of digital maps, overlays, voice, text and video. The enroute operator can “push” or “pull” information to and from forward forces. The enroute force can rehearse, share, and exchange information internally as well as with the sustaining base via connectivity with the DISN.[9]

Objective Force command, control, communications and computers (C4) in 2008 is more than just communications “pipes,” computer hardware and command and control applications. C4 establishes an integrated, ubiquitous network, managed and defended as an enterprise, with knowledge-based processes to empower Army and Joint users.

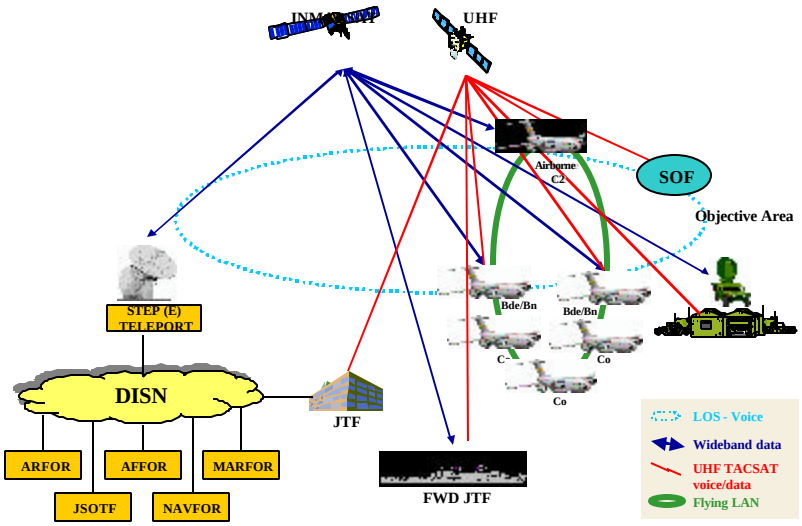

FIGURE 1. C2OTM ARCHITECTURE

EARLY / FORCED ENTRY PHASE

Early entry combat forces secure the area of operations and establish the arrival site for follow-on deploying forces. The force must be lethal, survivable and tailored to carry out initial combat operations to secure airhead, beachhead or lodgment areas. Follow-on forces typically expand lodgments and build up combat power to conduct extended combat operations. The brigade is the Army’s preferred organization for conducting such operations. Since the brigade will initially have limited combat power, it may rely on the other services for fire suppression and support (e.g., close air support and naval gunfire). Chernek goes on to describe the role that tactical radios, specifically SATCOM have in establishing the early entry force.

> "Our response to hostilities must be quick and decisive. SATCOM systems must be immediately available to our forces upon their arrival into an area of responsibility. The Early / Forced Entry forces must be prepared to fight their way in, and soon after arrival, expand their battlespace. The most demanding entry in this phase is via passenger/equipment airdrop. In addition to weapon systems, initial communications gear is carried with the forces being dropped, thus, requiring the communications systems to be small and lightweight. Combat Net Radio systems are utilized to coordinate actions of units who remain within close proximity of each other. Soldiers desire that future systems be of handheld size, have the capability of being secured to a belt, or placed in a uniform pocket, be capable of operating while on-the move, and allow hands-free operations capabilities. Communications with the ground forces, commanders in aircraft and other services must be continuous, secure and uninterrupted, thus the need to pursue advanced Extremely High Frequency (EHF) single channel systems, which will be discussed later in this paper. Once the ground situation is stabilized, the JTF and Army Forces (ARFOR) Main and Assault Command Posts are established. In an effort to protect the forces, these command posts will be widely dispersed and may not necessarily all be located where forces are engaged."[10]

ENROUTE MISSION PLANNING AND REHEARSAL

A critical command and control Objective Force enabler for both Enroute Forces and Early / Forced Entry Forces will be the Enroute Mission Planning and Rehearsal (EMPR) capability. EMPR is defined as capabilities that allow warfighters to develop plans, virtually rehearse the plans and using collaborative software, maintain situational awareness of the objective area while enroute or deployed on strategic or theater air, sea or ground-based platforms. EMPR capabilities also allow the warfighter to issue new orders and/or make changes to orders issued by higher headquarters based on the most recent intelligence. The EMPR capability includes a SECOMP-I communications package that will provide the service and Joint communication connectivity for both voice and data between the deploying units and their sustaining or intermediate staging area higher headquarters and forces operating in the area of operations. It will also provide a LAN connecting aircraft in-flight during deployment of the unit. This provides an inter-aircraft network that allows the commander to collaborate with subordinate leaders in separate aircraft.[11]

The EMPR capabilities include the applications and hardware that will enable Army, Joint and other command and control systems to operate over the communications system provided by the SECOMP-I. Some of the EMPR capabilities include the Department of Defense Collaborative Tool Sets (DCTS) and the applications associated with ABCS. This will allow the warfighters to receive and display continuous updates of the Common Operational Picture

(COP) and share the picture with all the leaders in the deployment. The DCTS will allow the coordination and virtual rehearsal of new or existing plans.[12]

The current and Objective Force requires the ability to conduct real-time and near real-time mission planning enroute to an area of operations. The Objective Force requires a higher threshold of information and eventually knowledge, than is currently available to successfully accomplish its mission. Its operational construct assumes that U. S. Forces will have Information Superiority. The EMPR capabilities support BCOTM that focuses specifically on the strategic and theater deployment of forces.

The Army, whether acting as a sole element, part of a Joint force or in concert with other government agencies, must be ready to undertake a variety of missions. Military operations short of full-scale war are generally confined to a specific geographic area and are often characterized by constraints on the forces, weapons and tactics employed and the level of characteristics that affect command and control function. These military operations provide singular challenges to enroute command and control where the situation is very fluid and can change rapidly from peace to war. Enroute command and control in these military operations needs to be flexible in order to provide mission support in a diverse environment with limited personnel and equipment**.**

Early and forced entry forces currently spend as much as 46% of their time between notification and the execution phase enroute to the area of operation.[13] An “information blackout" during deployment operations inhibits deploying forces during the critical last hours of a strategic deployment. Warfighters require the ability to plan and conduct Rapid Decisive Operations to include synchronized fires and effects. With the dynamic and fluid nature of the operational area, the Army needs the capability to maintain and increase situational awareness.

Force Projection doctrine requires Stryker Brigade Combat Teams to deploy strategically to an area of operations within 96 hours. An important characteristic of crisis response is to conduct a variety of missions in a time-sensitive environment in undeveloped theaters. Entry through multiple, unimproved air and seaports will present significant dilemmas to the enemy. The EMPR capability provides commanders with the ability to receive operations and intelligence updates enroute. They can conduct collaborative planning with multiple headquarters Unit(s) of Employment (UE), ARFOR, JTF and forward elements. They can share situational awareness across the force, then disseminate and rehearse the mission changes among combat forces while enroute to the objective area. It gives commanders the flexibility to adjust mission plans to meet changing situational environments and contribute to the achievement of information superiority. The ability to plan, coordinate, virtually rehearse and

execute must extend from JTF headquarters to echelons below the maneuver brigade (UE/Unit of Action (UA)). Therefore, the interface for command and control information must exist from the maneuver brigades to their respective maneuver and support force's tactical operations centers. Commanders and staff of deploying units must bring with them the necessary communications and battlefield functional area automation to provide the EMPR capabilities. EMPR capabilities support the commander with dedicated "on-the-move" situational awareness and to display both the COP and the simulations for the planned execution of the mission. The SECOMP-I / EMPR capability establishes a C4 network compatible with the following services:[14]

- Classified Global Information Grid environment
- Commercial networks (terrestrial, fiber-optic and space-based systems)
- Network security transparent infrastructure (detect, react, respond, defense-in-depth against computer network attacks)
- Transport of large volumes of information (voice, data, imagery, graphics and video)
- Near Real-time Beyond Line of Sight (BLOS) transmission while on the move
- Near-real time collaboration at the tactical level
- BCOTM, execution centric architecture
- Dynamic Network Reconfiguration (network tailoring, uninterrupted communications)

Limitations of EMPR capabilities will exist during heavy force operations when commanders and their troops are deployed via Civilian Reserve Aircraft Fleet and their equipment arrives via separate means. Another limitation is the fact that there are currently no organic command and control systems provided to the light force company level commander. However, ABCS is being reviewed to provide this capability in the future.

While enroute to an area of operations, EMPR capabilities allow receipt of near real time data and sharing of intelligence that will enhance the warfighter's immediate ability to fight off the ramp. Deploying forces will continue to refine their mission using the same organic command and control system that they used in garrison while enroute to the objective area aboard Air Force C-130 and C-17 aircraft or Army maritime vessels.

The ability to objectively maintain seamless connectivity for planning for mission execution from garrison, enroute and into a hostile mission area is imperative. EMPR capabilities include the communications and command and control software which allow the commander and all operational elements to accomplish the following:[15]

- Receive continuous updates of the COP
- Modify mission plans based on new or modified information
- Maintain common situational awareness among participants
- Coordinate new plans among all operational participants
- Synchronize and integrate combat power and assets
- Rehearse new or existing plans with all operational elements
- Receive new or modified mission taskings
- Use Joint collaborative tool sets
- Monitor execution of new plan
- Execute Joint fires
- Coordinate with Coalition Forces, Country Team(s), Non-Government Organizations
- Share information and synchronize operations using a flying/floating LAN

Once deployment commences, deploying forces plug in their C4 systems on the aircraft or Army maritime vessel using the pre-wired outlets for power and antennae connections. The deploying forces connect their organic command and control systems, using common EMPR applications, to the communication package and re-establish their voice and data networks among themselves and their appropriate headquarters. The deploying forces will continue to refine their mission using the same organic command and control system that they used in garrison while enroute to the objective area.[16]

THEATER SUPPORT VESSEL

As with enroute forces onboard aircraft, the TSV (Figure 2.) is another one of the key enablers that will allow commanders to operationally move and control combat power with precise sustainment into unpredictable entry points inside the theater of operations. It is the perfect complement to lighter and more agile Army forces. Combat forces can be delivered autonomously on the TSV, planning and rehearsing enroute and arriving at the destination capable of immediate action. As a high-speed delivery vehicle, for example, a TSV can deliver fuel and supplies uploaded on trucks that can drive off and rendezvous with a combat force at a mission staging area.

To expand the TSV's operational possibilities, the EMPR / SECOMP-I capability will be an integral part of the vessel. This feature will allow real-time information to be received. Units onboard will receive new or changed missions, get intelligence updates, collaboratively plan with headquarters and forward elements as well as conduct rehearsals while enroute to the

entry point. Deploying units will arrive not only mission capable, but already integrated into the joint force commander's operation. Most important, a C4ISR package will provide the command and control necessary to manage the critical early entry piece of the deployment.

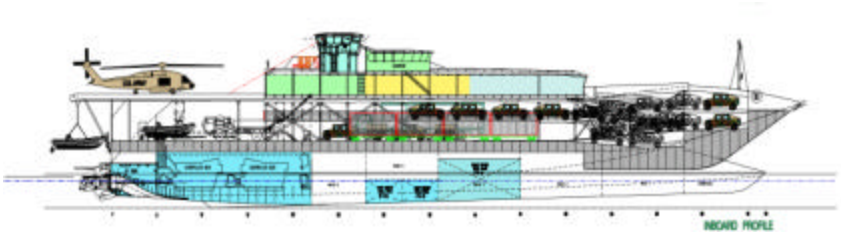

FIGURE 2. THEATER SUPPORT VESSEL

Information from a variety of sources will allow the TSV to exploit any small port within a thousand mile arc. With a measure of force protection gained through foreknowledge and speed, the TSV can be where the enemy is not, delivering forces and sustainment. In many ways, the TSV reflects the essence of Army Transformation. Whether delivering combat power intact, sustainment or humanitarian and disaster relief, the TSV is the appropriate solution to make our current and future Army more strategically responsive.[17]

OBJECTIVE FORCE WARRIOR

C2OTM will extend to the ground-based platforms via the Objective Force Warrior and a myriad of tactical ground vehicles including the Stryker. Objective Force Warrior integrates small arms with high-tech equipment enabling ground forces to deploy, fight and win on the battlefields of the 21st century. Objective Force Warrior came about in 1991 when an Army study group recommended the service look at the soldier as a complete weapon system. The first priority in Objective Force Warrior is lethality. The second is survivability and the third, command and control.

Based on recent advances in communications, sensors and materials, the Objective Force Warrior integrates commercial, off-the-shelf technologies into a complete soldier system. (Figure 3.)

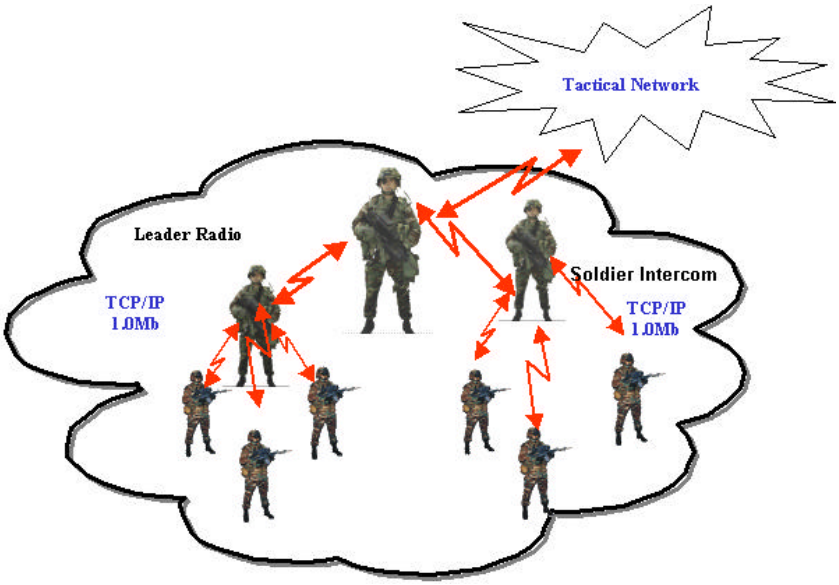

FIGURE 3. OBJECTIVE FORCE WARRIOR NETWORK.

For the first time, the soldier's equipment is being designed as if he is an individual, complete weapons platform. Each subsystem and component is designed to and for the soldier. The result is the first integrated soldier fighting system for the dismounted infantryman[18].

Objective Force Warrior has several subsystems: the weapon, integrated helmet assembly, protective clothing and individual equipment, computer/radio and software. The weapon subsystem is built around the M-16/M-4 modular carbine. The weapon subsystem includes key electrical optical components such as the Thermal Weapons Sight, video camera and the laser rangefinder/digital compass (LRF/DC). The LRF/DC provides the soldier with range and direction information. When coupled with the individual location from the Global Positioning System (GPS), the soldier has accurate target location when calling for indirect fire and combat identification. This system will allow infantrymen to operate in all types of weather and at night. In conjunction with other components, a soldier can even shoot around corners without exposing himself to enemy fire.[19]

The Integrated Helmet Assembly Subsystem (IHAS) uses advanced materials to provide ballistic protection at less weight than the current helmet shell. The integrated helmet assembly is lighter and more comfortable than today's helmet. The IHAS's helmet-mounted computer and sensor display is the soldier's interface to the other subsystems and to the digital battlefield. Through the helmet-mounted display, the soldier can view computer-generated graphical data,

digital maps, intelligence information, troop locations and imagery from the weapon-mounted Thermal Weapons Sight and video camera. This new capability allows the soldier to view around a corner, acquire a target and then fire the weapon without exposing himself beyond his arms and hands to the enemy. By scanning an area with the weapon's thermal sight, the soldier will be able to see an area's characteristics, including terrain and enemy positions and will be able to see through obscurants. The thermal images will appear on a miniature helmet-mounted display. The Night Sensor Display will integrate a helmet-mounted display with an image intensifier for access to the computer sensors as cited above. This will allow the soldier to maneuver and engage targets under cover of darkness.[20]

The Protective Clothing and Individual Equipment Subsystem consists of a revolutionary backpack frame design based on state-of-the-art automotive racing technology that bends with the soldier's natural body movements. The cables are integrated into the frame as necessary for the soldier's computer/radio connections. The soldier can adjust his backpack frame to adjust the load distribution from his shoulders to his hips while on the move. This is a simple adjustment, yet it allows the soldier to manage and carry his combat load more effectively and with less fatigue. The new Objective Force Warrior body armor, like the helmet, provides improved ballistic protection at a reduced weight. The Objective Force Warrior body armor includes a modular upgrade plate to protect the soldier against the small arms threat. The protective clothing and individual equipment subsystem incorporates modular body armor and upgrade plates that can stop small arms rounds fired point-blank.[21]

The infantryman will attach the Computer/Radio Subsystem (CRS) to the load-bearing frame. Over this goes the rucksack for personal gear. The computer processor is fused with radios and a GPS locator. A hand grip wired to the pack and attached to the soldier's chest acts as a computer mouse and also allows the wearer to change screens, key on the radio, change frequencies and send digital information. The subsystem comes in two versions: The leader version has two radios and a flat panel display/keyboard, while a soldier version has one radio. With the equipment, leaders and soldiers can exchange information. Soldiers using their weapon-mounted camera, for example, can send videos to their leaders. In its Generation II version, the computer and radio will be combined and embedded in new web gear. The system will be built around a series of cards the size of a credit card, but slightly thicker.

The CRS is integrated into the backpack frame in two sections. The upper portion contains two radios (the squad radio and the soldier radio). The squad radio is based on a repackaged commercial radio and will be fully compatible with SINCGARS System Improvement Program (SIP) and future JTRS. The soldier radio is based on a repackaged

handheld commercial radio. This gives the soldier the ability to communicate with others in the squad, greatly improving situation awareness and survivability through increased command and control. The lower portion of the backpack contains the computer and GPS modules. Integration of the GPS and radio into the CRS eliminates separate displays, controls and cases, thereby saving weight and reducing power requirements. The soldier controls the menu driven displays from the Remote Input Pointing Device. This device is located on the chest strap and is operated by the touch of a finger. Some functions are controlled with two buttons located near the trigger finger, allowing the soldier to maintain a firing position. Imbedded into the load-carrying frame are the antennas for the GPS and soldier radio. The open architecture of the CRS allows direct insertion of future upgrades in both hardware and software.[22]

STRYKER

The first tactical vehicle developed under the auspices of “Army Transformation” is the Stryker, a wheeled personnel carrier with multiple variants. The command and control heart of the Stryker vehicle is the FBCB2 digital communications system, "the tactical internet.” The system allows communication between tactical vehicles and TOCs through text messaging and a map network. The map shows the position of all vehicles on the battlefield and the commander can mark the position of enemy forces on the map that can then be seen by other commanders. The Stryker driver has three M-17 periscopes and a Driver's Vision Enhancer, a heads-up display device. The vehicle commander has seven M45 periscopes and a thermal imager display with video camera.[23]

The essence of what Stryker and its new situation awareness capability brings to the fight is summed up in the following comments by Brig. Gen. John M. Brown III, Deputy Commanding General for Transformation and Deputy Director for Army Transformation Experiment 2002.

> "I can see sitting where you are, what the driver sees as he goes forward. I can see what the commander sees through that weapon sight. And when he goes over to the FBCB2, when he goes to that, if we were up and operating, I'd see icons on that virtual map - the blue dots where we're sitting right now and I would also see an icon that showed me where every one of the other Strykers are in my unit. I'd see where enemy spot reports had been plotted on the map."[24] (Figure 4.)

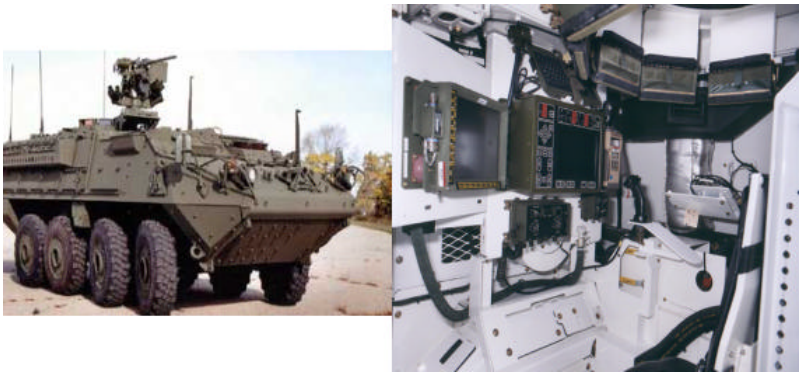

FIGURE 4. STRYKER VEHICLE

> "So when I came out of the back of this vehicle, I'd have a tremendous greater level of confidence and knowledge about what's out there and what we're going to face than we've ever had in the eyes of the force before at the infantry soldier level. We're going to see a whole new capability of integrating information far beyond what we've had in the field in the past. You're going to see the ability of planners, units located in dispersed geographic locations, to plan simultaneously using movement of information from headquarters-to-headquarters more rapidly than we've ever done before."[25]
>
> —Brigadier General John M. Brown, III

TECHNOLOGICAL ADVANCES

As alluded to earlier, the government, industry and academia are seeking alternatives to the saturated Very High Frequency (VHF) and UHF spectrums for providing more robust communications throughput. Major strides have been made in the spectrum and processing arenas and the prospects offer tremendous promise in terms of supporting the future demands of the Objective Force. The following applications have demonstrated significant potential such that academia, industry and the government have invested considerably in further development of the capabilities.

SATCOM ON THE MOVE

The robust BLOS connectivity delivered by the Military Strategic and Tactical Relay (MILSTAR) satellite system makes EHF SATCOM a logical choice for providing the communications support necessary to conduct operations in support of the Objective Force. However, in order to be most effective at the tactical level, MILSTAR services must be extended to support C2OTM. Due to the fact that MILSTAR operates at EHF, this task poses two

significant technical challenges. First, path losses are higher at EHF compared to other frequency bands. Consequently, EHF terminals typically use directive antennas (e.g., parabolic dishes) for increased gain. The use of directive antennas implies that they must be pointed accurately for maximum benefit which is a significant task on a mobile platform, especially when a cost effective solution is required. Second, the shorter wavelengths at EHF imply that these signals are easily scattered and absorbed by objects in the propagation path such as buildings or foliage. Hence, error control and other baseband signal processing schemes to help mitigate these effects are essential for reliable C2OTM communications. The results of a feasibility study indicated that these challenges are not insurmountable. Consequently, MIT Lincoln Laboratory, Harris Corporation, and the U.S. Army Communications and Electronics Command conducted a field demonstration of EHF SATCOM C2OTM. As part of this effort, Lincoln Laboratory is engaged in the development and evaluation of baseband error control techniques.[26]

The dominant propagation effect for the EHF SATCOM C2OTM channel is signal fading caused by objects in the propagation path, as illustrated in Figure 5. This type of fading is often referred to as signal shadowing to distinguish it from fading caused by multi-path propagation.

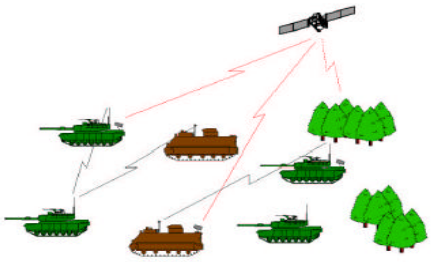

FIGURE 5. SATCOM ON THE MOVE

Other relevant propagation phenomena include path loss due to weather and other atmospheric affects. Although losses of this type are generally more severe at EHF compared to lower frequencies, they can generally be overcome with sufficient link margin. The effects of shadowing in the EHF band are more severe simply because the shorter wavelengths at these frequencies are more likely to be scattered than reflected, resulting in less energy at the receiver. The most comprehensive EHF propagation experiments conducted to date involved NASA's Advanced Communications Technology Satellite (ACTS). According to the ACTS results, typical mean values for the received signal power during shadowing are on the order of

20 dB below the non-shadowed signal power. With fading this severe, it is impractical to attempt to address the problem with raw link margin. A statistical description, referred to as the Total Shadowing Model, was proposed to characterize signal shadowing in an L-band mobile SATCOM system. The basis of the model is that SATCOM channel consists of two states: an "open" state (i.e., non-shadow region) where a Line of Sight (LOS) path exists and communications is possible and a "blocked" state (i.e., shadow region) where no LOS path exists.[27]

OTHER SCIENCE AND TECHNOLOGY EFFORTS

The concepts and technologies discussed in this paper are essential capabilities that the Objective Force must acquire in order to obtain information superiority and achieve our power projection goals. WIN-T and JTRS are programs that will provide the communications "backbone" necessary to satisfy the bandwidth demands of our robust tactical command and control systems. User owned and operated systems such as SECOMP-I will enable the commander and staff to maintain the same capabilities and level of functionality while enroute as they did in garrison. Additionally, industry funded Research and Development efforts and the Defense Advanced Research Projects Agency's Future Combat System-Communications technology initiatives have demonstrated significant C2OTM applicability. The following are some of the more promising technologies under development that will enable the Objective Force to command and control while on the move.

Technology	Benefit	Spectrum
Asynchronous Transfer Mode (ATM)	Seamless integration of mobile and fixed networking infrastructure	Baseband
Orthogonal Frequency Division Multiplexing (OFDM) Digital Receiver Architecture	Multi-carrier modulation (MCM) technique for JTRS in support of FCS	1 GHz and below
Adaptive Vector OFDM Waveform	FDMA\CDMA\TDMA technique that offers advantages of each plus a frequency hopping mode	Baseband
Low Band Radio Subsystem	Software defined, scalable and assured in all environments. LPD/AJ	20-3000 MHz
Low Band Antenna System	Antenna array that supports directional networked communications	30-2400 MHz
UHF Antenna Array over High Impedance Surfaces	Low profile, high impedance arrays for a variety of platform surfaces	225-450 MHz

Technology	Benefit	Spectrum
Wideband Millimeter Wave Radio	Supports wideband mobile adhoc battlefield networking. LPD\AJ	30-45 GHz
High Band Antennas	Affordable, electronically steered arrays. –10 thru +40 from boresight.	L-Band
P-MEMS 2D Scanned Surface Technology Antenna	Low cost phased arrays for high band subsystem. +/- 45 degree adjustment in beam direction.	L-Band

FIGURE 6. INDUSTRY AND ACADAMIA EFFORTS

CONCLUSION

The central issue this paper addresses is the command and control shortfall that enroute forces experience while on the move. Specifically, the current force does not possess the ability to arrive at its deployment destination prepared to act on mission changes that occur while enroute. The enroute Objective Force must be enabled with the most current intelligence which improves its ability to see first, understand first, act first and finish decisively. C2OTM is the fundamental functionality that will enable the Objective Force to arrive at its destination fully mission capable 96 hours after deployment.

To be responsive to the warfighter, C2OTM systems will provide global coverage, be rapidly deployable and improve mobility on the battlefield. The Objective Force C2OTM network will be designed to support every phase of our future operations to include mobilization, pre-deployment, enroute, early and forced entry, combat, sustainment operations, peace operations, re-constitution and re-deployment phases. Faster operations tempo, extended battlespace and more complex weapon systems require simultaneous planning and execution at all levels.

The desire for C2OTM is as old as the idea of radios on the battlefield. In the early 1900's, commanders realized that communicating via radios was a reliable means of instantaneously transmitting critical information over extended distances. However, the ability to transmit information over the entire battlespace while moving has been a seemingly insurmountable challenge and has endured even on today's modern battlefield. One hundred years after the first tactical radios were employed, the Army embarked on the monumental effort to transform itself. Transformation of the Army from a legacy force to the Objective Force will have the same impact as tactical radios, tanks and helicopters had on warfighting. Nevertheless, the possibility that a commander operating from an Objective Force tactical platform in the year 2008 has to stop to communicate is completely unacceptable.

A C2OTM network that links the enroute Objective Force to the sustaining base and forward-deployed forces is essential and prototype versions of the evolving capability are operational in Afghanistan supporting Operation Enduring Freedom and in Iraq supporting Operation Iraqi Freedom. The Secretary of Defense, Combatant Commander Central Command and the Commander, 18th Airborne Corps all have airborne prototypes of the EMPR capability on their command aircraft.[28] Coincident with the timeframe that this research was completed, the Department of the Army fully funded the SECOMP-I program and the inherent EMPR capability in the FY04-09 Army budget as a component of the FCS system of systems solution. Initial production units will be fielded in the FY05 timeframe with the first brigade equipped in FY07. The SECOMP-I / EMPR capability will be an enabler for the Objective Force as it meet its FY08 Initial Operational Capability milestone.

SECOMP-I is a spiral development program and the initial production units will be installed on Air Force C-130 and C-17 aircraft. The program is designed to accommodate installation on the Army's TSVs when the requirements are defined and resources permit.[29] As previously discussed, the ground-based Objective Force Warrior and Stryker requirements are hampered by "on the move" challenges that have not been resolved to date. However, leveraging the less populated EHF spectrum, development of blockage mitigation algorithms and improvements in processing ABCS and other situation awareness tools, directly address the ground-based challenge and have demonstrated great promise. Every indication is that ground-based C2OTM challenges will be resolved within the next two – four years. In light of the current programmatic accomplishments and demonstrated technical potential, the warfighter can have every confidence that C2OTM for the Objective Force will be a reality in 2008 across the entirety of the battlespace.

WORD COUNT = 6717

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[21]Ibid.

[22]Ibid.

[23]"STRYKER - Wheel Drive Armoured Combat Vehicles, USA", available from <http://www.army-technology.com/projects/stryker/>; Internet; accessed 5 January 2003.

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GLOSSARY

AOR - Area of Responsibility

AUSA – Association of the United States Army

BCOTM – Battle Command On-the-Move

BLOS - Beyond Line-of-Sight

C2 - Command and Control

C2OTM - Command and Control On-the-Move

C4I - Command, Control, Communications, Computers, Information

C4ISR - Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance

CNR - Combat Net Radio

CDMA – Code Division Multiple Access

COE - Common Operating Environment

CSSCS - Combat Service Support Control System

DARPA - Defense Advanced Research Projects Agency

DCTS – Defense Collaborative Tool Set

DII - Defense Information Infrastructure

DISN - Defense Information System Network

EHF – Extremely High Frequency

FBC2B2 - Force XXI Battle Command Brigade and Below

FCS – Future Combat System

FDMA – Frequency Division Multiple Access

GCSS-A - Global Combat Support System - Army

GIG - Global Information Grid

JTF - Joint Task Force

JTRS - Joint Tactical Radio System

LAN - Local Area Network

LOS - Line-of-Sight

SECOMP-I - Secure Enroute Communication Package-Improved

SINCGARS SIP - Single Channel Ground Airborne Radio System Improvement Program

STEP - Standard Tactical Entry Point

SUO-SAS - Small Unit Operations - Situational Awareness System

SHF – Super High Frequency

TCP - Transmission Control Protocol

TDMA – Time Division Multiple Access

TF - Task Force

TI - Tactical Internet

TIP - Theater Injection point

UE\UA – Unit of Employment \ Unit of Action

UHF – Ultra High Frequency

VHF – Very High Frequency

VTC - Video Teleconferencing

WAN - Wide Area Network

WIN-T - Warfighter Information Network – Tactical

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